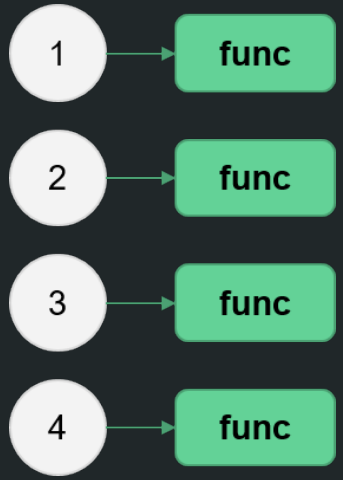

Parallel Python

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ASPP 2025, Plovdiv

Fork/clone the repo now!

Outline

- Processes, threads and THE GIL
- Hands-on investigations of embarrassingly parallel problems
    A. Multithreading with NumPy
    B. The `multiprocessing` package
    C. Blending processes and threads
- Going further
- Wrap-up

Exercise: brainstorm

Why do we parallelize?

Talk to your partner and come up with three practical examples of where parallelization could be beneficial (in your work or another application).

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In short, two reasons why:

- Speed up computations.
- Process “big” things.

As for the “how”...we’ll come back to that later.

Processes, threads and the *GIL*

Kitchen-2-Computer analogy

Customer
Gives orders

Large Pantry
across the street

Big Countertop
temporarily holds things

Workstation
Includes chef, tiny countertop and tools

Transport servants
Carry stuff

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Talk to your partner:
What is what?

The шопска салата program.

We need to make a single dish:
шопска салата.

This requires:

1. Fetch vegetables from pantry
2. Wash vegetables
3. Fetch cheese from pantry
4. Grate cheese
5. Chop vegetables
6. Combine veggies and cheese
7. Place salad in the pantry

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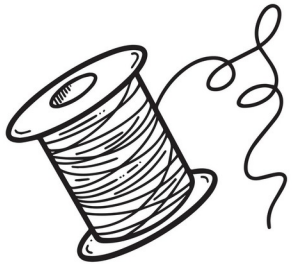
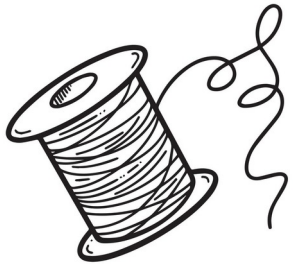
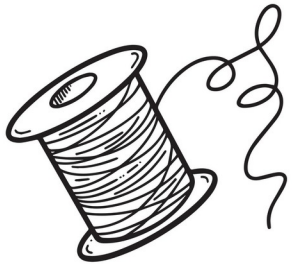
Talk to your partner:
How can we make шопска салата faster?
Without kitchen renovations

Yay! We have just designed a

multi-threaded program

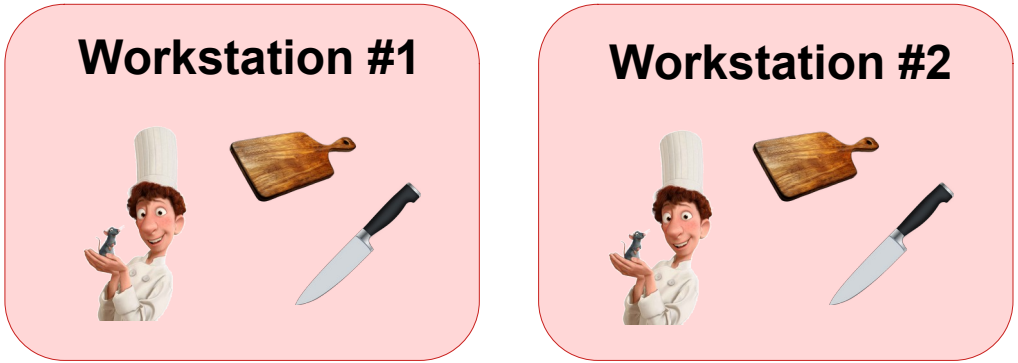
The restaurant owner made the kitchen larger!

Workstation #1

Workstation #2

Countertop (memory)

The restaurant owner made the kitchen larger!



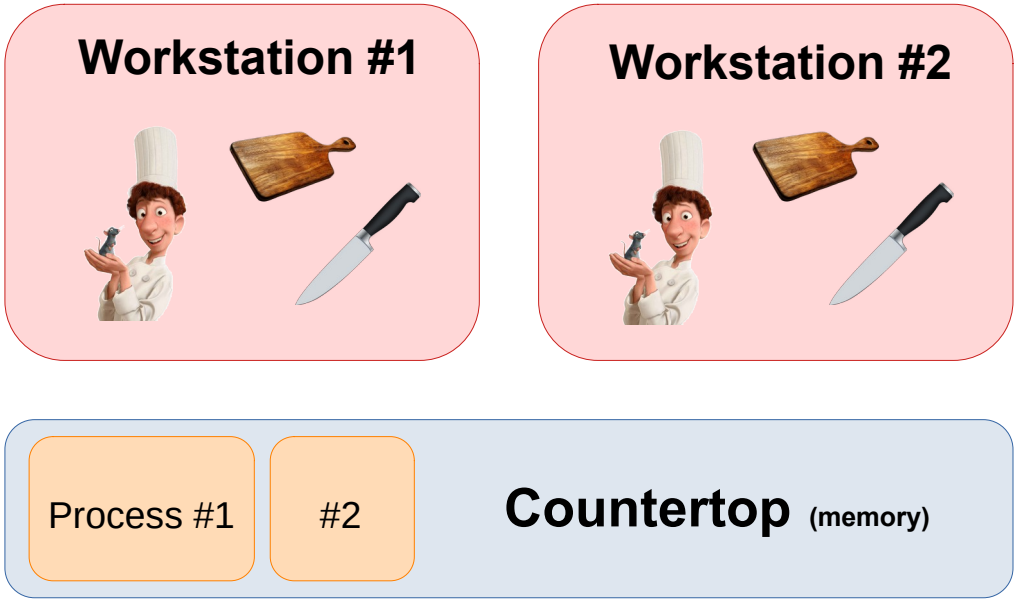
Problem #1:
Memory corruption

Problem #2:
Race conditions

Race conditions

(Live coding)

Solution #1: Protect the memory

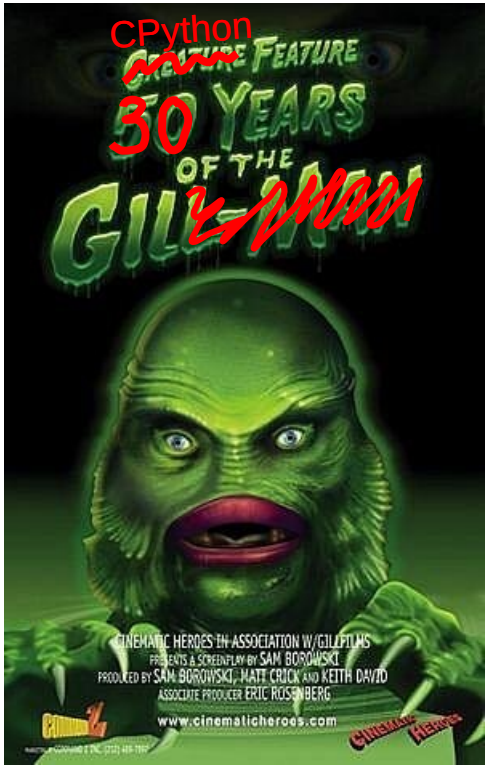


<u>Multi-processing:</u>
Each process gets assigned <u>private memory</u>, other processes cannot read or write from it*, if they try there will be an error (*Segmentation Fault*)

*usually

Who does this?
The Operating System (OS)

Python’s solution: The *Global Interpreter Lock* (GIL)



* A mutual exclusion (mutex) lock.

* Within the Python process, only 1 thread is allowed to execute **pure-Python code** in a given instance.

* The lock is acquired and released by threads, approximately every 100 bytecode instructions. Also released in other cases, e.g., I/O.

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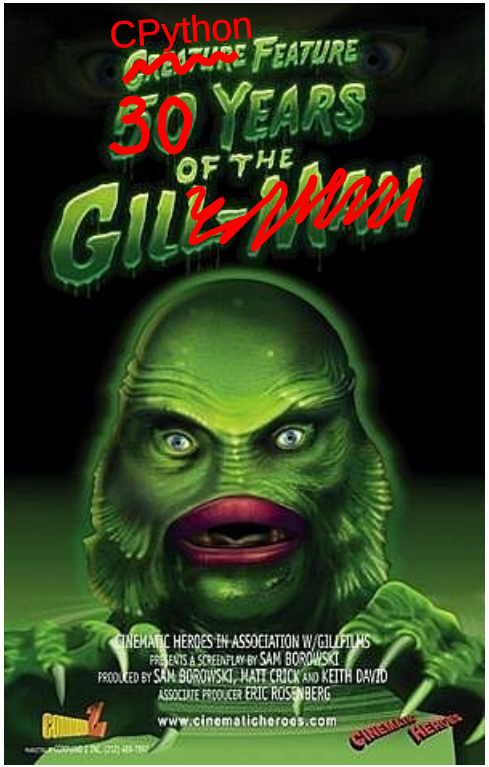

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Hypothesize with your partner:
NumPy can (and by default does) run code with multiple threads in parallel. How is this possible?

NumPy’s trick

NumPy interfaces with non-Python libraries that, by default, use as many threads as you have cores.

In other words, it is *many* threads disguised as one!

Process

* List of instructions, i.e. an instance of some program
* Has private memory
* Can be made up of one or more threads
* Is not a physical part of the computer, it is defined by the rules of the OS

Thread

* Some instructions from the program (all instructions if single-threaded)
* Always part of a process
* Shares memory with other threads of the same process

Processes and threads do not run on a specific CPU,
the OS will allocate them and can move them mid-run

To wrap things up...a pop quiz!

On your pair computer, please navigate to **play.blooket.com** and enter game pin

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